INFLUENCE OF MVTR OF AIR-SIDE LAYER OF BACKSHEET ON THE RELIABILITY OF BACKSHEET ITSELF AND CONSEQUENTLY ON THE RELIABILITY OF SOLAR PV MODULE

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ABSTRACT: Moisture Vapour Transmission Rate (MVTR), also called Water Vapour Transmission Rate (WVTR) of air-side layer of PV Backsheets plays a significant role on the performance and durability of Backsheet and consequently on the reliability of the PV module. This study reveals that the performance and the reliability of photovoltaic modules are highly influenced by the MVTR of the air-side layer of Backsheet if the core layer of the Backsheet is Polyester based.

The Backsheet manufactured using air-side Hydrolysed PET (HPET) layer having lower MVTR value shows less hydrolytic degradation of the core layer PET as compared to Backsheet made of Fluoro materials as air-side layers having higher MVTR value. Backsheets with air-side layer having lowest MVTR shows lowest degree of hydrolytic degradation irrespective of types of Backsheets. The Backsheet with structure HPET / PET / Priming layers shows better hydrolytic resistance than all remaining Fluoro based structures considered in the study. The Solar PV module having HPET / PET / Priming layer Backsheet showed lowest power loss (max 3%) up to damp heat 2500hrs. Whereas, the Modules made using Backsheet structure with Fluoro polymer as airside layer having higher MVTR value (Fluoro-2 / PET / Priming layer & Fluoro-3 / PET / Priming layer) showed more power loss (>5%) after the DHT of 2500hrs. Cracking of core layer PET was observed in the modules made using Backsheets with Fluoro materials. Backsheet structure with Fluoro-1 polymer having lower MVTR value (Fluoro-1 / PET / Priming layer) showed power loss < 4 % after the DHT of 2500hrs. In this study we found that when Fluoro materials are used in the Backsheet as sir-side layer, it remains stable itself for a longer time but due to its poor moisture barrier, the core layer PET of the Backsheet gets hydrolysed faster with time. This phenomenon of hydrolysis reduces the mechanical strength of the core layer PET causing mechanical cracks. Once the cracks in the Backsheet are developed, it leaves almost no protection towards moisture ingress from climate to the module, causing rapid degradation in the cells and interconnects reducing the performance and the durability of the module.

Keywords: PV Module, Reliability, Backsheet, MVTR, Hydrolysis

1 INTRODUCTION

The MVTR of a Backsheet is the net resultant of MVTR of each laminated layer used in the construction. The net resultant of MVTR of the Backsheet is always lower than the layer of lowest MVTR. Most commonly used Backsheet constructions now-a-days are typical three layers Backsheets. Considering from the air side, the first two layers of the Backsheet are the ones contributing to MVTR majorly. The third layer is generally EVA priming layer which contributes very little to the MVTR but it is the key material for the adhesion with EVA. The air side layer (outer layer) of the Backsheet is generally chosen for imparting high UV stability and high hydrolytic resistance. Least importance is given on the moisture barrier property for this layer. Fluoro based materials are preferred for air-side layer for having high UV stability and hydrolytic resistance. But, the MVTR of most of the Fluoro material are very poor in comparison to Polyester films. The most commonly used core layer in Backsheets is Polyester (PET) film. PET exhibits good mechanical strength and electrical insulation properties required by solar PV modules, but it is highly prone to hydrolytic attach in the presence of heat and humidity.

The MVTR of the Backsheet is mainly depend on the MVTR of each layers used in its construction. The most commonly used material in backseat is PET as middle layer while PE as a Priming layer and Fluoro & HPET as air side layer. Since the middle PET and priming layers are common in Backsheet, so the effect of MVTR of air-side material will be the main variable towards varying moisture ingress for this study. The present study involves the study of hydrolysis test of different Backsheets and Damp Heat Test (DHT) of the modules manufactured using these Backsheet constructions. The selected Backsheet constructions for the study were 1st. Fluoro-1 / PET / Priming layer, 2nd Fluoro-2 / PET / Priming layer, 3rd. Fluoro-3 / PET / Priming layer and 4th. HPET / PET / Priming layer. The Backsheets involved in this study were having identical core and priming layer. The air-side layers were the variable parameter for the study. The power degradation of solar PV modules with respect to MVTR of air-side layer of Backsheet was analysed. The power measurement and visual inspection were done for Solar PV module after every 1000 Hrs. intervals. The degrees of hydrolysis of Backsheets were compared by measuring the retention in Tensile Strength & Elongation post PCT (Pressure cooker test) after 48 Hrs.

2 EXPERIMENTAL PROCEDURE

Different Backsheets were prepared having identical middle PET and Inner priming layer. The Air-side layers were different in each structure (Table-1)

Backsheet Sample id	Backsheet Samples for Study		Total Thickness	Backsheet MVTR (g/m2-day)
	Layered Structure (thickness-µm)	Air side layer MVTR (g/m2-day)		
Fluoro:1	F(25)/PET(190)/Priming(100)	34.2	295 µm	1.6
Fluoro:2	F(25)/PET(190)/Priming(100)	54.2	295 µm	1.7
Fluoro:3	F(20)/PET(190)/Priming(100)	93.4	290 µm	1.9
Non-Fluoro	HPET(50)/PET(190)/Priming(100)	11.6	360 µm	1.5

Table (1): Backsheet Structure for experiment

The MVTR of each air-side layer and their corresponding Backsheet were measured. The Hydrolysis test (Pressure Cooker test) of each Backsheet was done to understand the effect of moisture ingress from air-side to middle layer PET. The tensile strength and Elongation of each Backsheet sample was measured by UTM (Universal Testing Machine).
Solar PV module with these Backsheet was prepared at the common set-up at the same time using all identical materials excepting the Backsheets. The modules were subjected them to Damp Heat Test for 2500 Hrs. The Power of the module was measured pre and post damp heat test up to 2500 Hrs.

3 RESULTS & DISCUSSIONS

3.1 MVTR study

MVTR of four different airside layers has been measured at 38 °C & 90% Rh. Figure (1) shows MVTR of each layers.

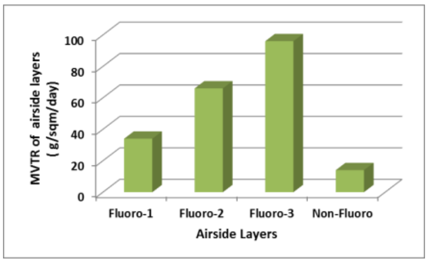
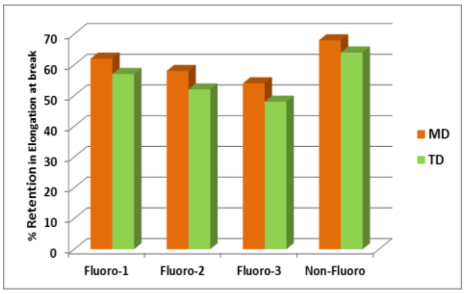


Figure 1: MVTR of Air-side layers

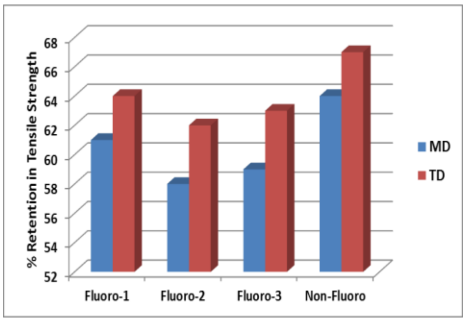
Out of the four air-side layers, Hydrolysed PET film is having lowest MVTR because of its higher thickness and its material nature. MVTR of Fluoro-3 is almost 50% more than Fluoro-2. Fluoro-2 has 5 mic more thickness that Fluoro -3. Fluoro-2 is a three layer material while Fluoro-3 is mono layer. The MVTR of Fluoro 1 film is almost 35% less than Fluoro-2 and both Fluoro-polymers have 3 to 5 times more MVTR than HPET(Non-Fluoro) respectively.

3.2 Hydrolytic Resistance test of Backsheets

The hydrolytic resistance is measured by testing the retention of Tensile Strength and Elongation of Backsheets post hydrolysis test. Figure (2a) shows the retention % of elongation in MD & TD of the Backsheet post PCT 48 hrs test. Figure (2b) shows the retention % of Tensile Strength in MD & TD of the Backsheet post PCT 48 hrs test. The PCT test condition was Temperature- 121°C, %RH-100%, Total pressure on sample- 2bar and test duration 48 hrs.



2 (a)



2 (b)

Figure 2: (a) Retention of elongation (b) Retention of Tensile Strength of Backsheet post hydrolysis test

Results indicate that Backsheet having lowest MVTR air-side layer showed the best resistance to hydrolysis. Since the mechanical properties of Backsheet strongly depend on middle PET, higher the mechanical retention, lower the hydrolytic degradation of the middle layer PET. It is clear from above results that the HPET layer having lower MVTR allows lesser moisture as compared to other air-side layers. Since the priming layer is identical in all Backsheets, its effect is same in all Backsheet and the effect of change in MVTR of airside layers is majorly reflected. The hydrolysis mechanism of PET is shown below:

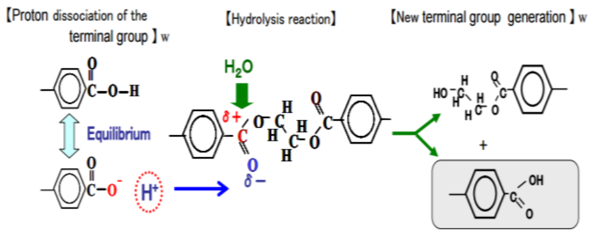


Figure 3: Hydrolysis mechanism of PET [1]

In the presence of water and heat for a long time, the ester bond between Terephthalic acid and Ethylene Glycol breaks making polymer chains weak and as a result the polymer starts becoming brittle.

3.3 Damp Heat Test on Solar PV modules

The back sheets with different air-side layers were used for making modules of 100 Wp power. With each Backsheet, 2 modules were made and kept in DHT chamber. The power was measured pre and post Damp Heat Test. The average loss in power is plotted in Figure (4).

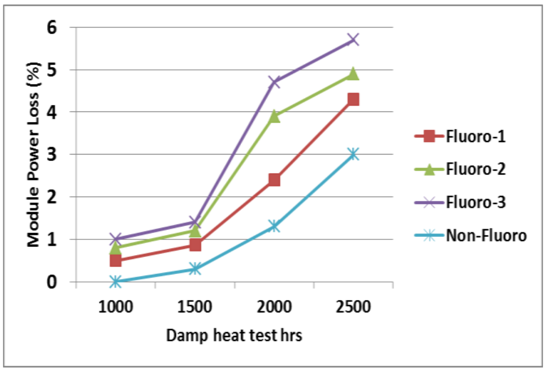


Figure 4: Power loss (%) post DHT

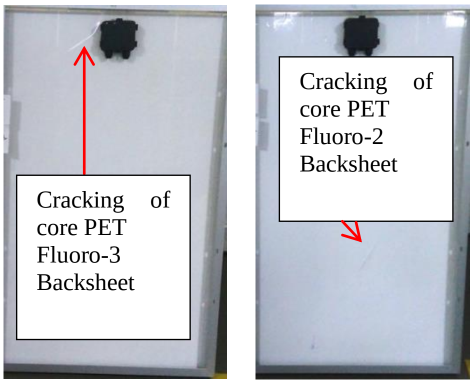


Figure 5: Cracking of Backsheet post DHT 2500 hrs

As shown in the above graph (fig-4), there is no power loss in the Backsheet with non-Fluoro Backsheet till 1000 Hrs. The rate of power loss in all Backsheet is equal till 1500 hrs of DHT exposers. But post 1500 Hrs, there is a difference in the rate of power loss. The rate of loss has increased significantly in the modules having Backsheet with lower moisture barrier – those having higher MVTR in air-side layers. Whereas, the same is not so steep in the module with Backsheet having higher moisture barrier air-side layer (lower MVTR). After 2500 Hrs of exposure, the power losses in the modules having Backsheets with poor moisture barrier is over 4% and go up to 6 %, whereas the same is max 3% in module having Backsheet with higher moisture barrier.

Fluoro materials having higher MVTR (Fluoro-2 & Fluoro-3) found intact themself till 2500 Hrs. but due to its poor moisture barrier, the core layer PET of the Backsheet, got hydrolysed with 2500 Hrs. The phenomenon of hydrolysis reduced the mechanical strength of the core layer PET which caused mechanical cracks [2] as shown in figure (5).

4 CONCLUSION

In both the experiments it is proved that MVTR of Backsheet and Backsheet layers play major roles in reliability of solar PV modules. Lower the MVTR, the better the reliability of the PV modules in the field under adverse climatic conditions. It is important to give due consideration to the MVTR of air-side layer whilst designing Backsheet construction.

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